DESIGNING A VISUALIZATION BASED LEARNING APPROACH FOR LEARNING ENGINEERING DRAWING

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ABSTRACT

The purpose of this research was to design a Visualization-based Learning Approach (VAL) in learning Engineering Drawing (ED) specifically for the topic auxiliary view (AV). The research comprises three phases, that is, (i) Phase I is to determine students' levels of difficulties in ED topics, (ii) Phase II is to identify students' cognitive visual levels and AV problem solving methods which is then used to develop the pattern of problem solving methods in ED among students of various cognitive visual levels; (iii) Phase III is the development of VAL. The fundamental theories used in this research are Wiley Visual Cognition Stage, Auxiliary View Problem Solving Approach and Visual Literacy. Both qualitative and quantitative approaches are used to collect the data. The research samples consist of 43 Engineering Drawing teachers in Phase I and 350 students in Phase II . The research instruments used for data collection include questionnaires, tests and interviews. Quantitative data were analyzed using SPSS while qualitative data were analyzed using triangulation method in single-case and cross-cases. Results were presented as percentages, frequencies, means and transcripts. The findings of Phase I showed that the topic of AV is one of the topics in Engineering Drawing with high level difficulty. Results of Phase II showed the descending order of students' visual cognition levels from visual memory, visual perception to visualization. The results also showed that the students used a combination of principles of projections,

imagination and sketching to solve Engineering Drawing problems. The evaluation of the effects of using Visualization-based Learning Approach will be conducted to enhance students learning ED especially for the topics requiring visualization skills.

INTRODUCTION

Visualization intelligence is the ability to 'read,' interpret, and understand information presented in pictorial or graphic images, then apply both physical and mental images in thinking. As a result students with high visualization intelligence find it easier to comprehend information and communicate it to others. Many researches have been done by the psychologies and educators also stressed that visual learning is an effective teaching strategy for different ages students in enhancing their thinking and learning (Inspirasi, 2004). This might be almost 90% of brain sensory input is visual (Hopper, 2003).

According to Wiley (1990), although the visualization intelligence is born but the visualization skills could be train through practice. The visualization skills determine how well a person perceives visual patterns and extract information for further use. Visualization also facilitates the ability to form associations between pieces of information something which helps improve long term memory. Thus, this skill is very important for those who learn ED and achieve the success in this subject because it relates between theory and the picture of reality. It will provide an accurate and complete picture for every object in terms of shape and size (Widad & Adnan, 2000). Giesecke (1995) also reported that ED requires a mind with the ability to see an image in 3-dimension. Information and specifications from the real object must be transferred to a drawing. Likewise, interpretation of information from a drawing to produce a reality must occur. The transfer from reality to a drawing and vice versa is not an easy task. It requires a teaching-learning process that encourages the use of mind literacy; that is, the use of both hemispheres in thinking. Problem solving using the mind literacy thinking style will generate students who are innovative, creative, critical and dynamic (Widad & Adnan, 2000).

Purpose of Research

The purpose of this research was to design a Visualization-based Learning Approach (VAL) in learning Engineering Drawing (ED) specifically for the topic auxiliary view (AV). The fundamental theories used in this research are Wiley Visual Cognition Stage, Auxiliary View Problem Solving Approach and Visual Literacy. The specific of this research were:

1. To determine students' levels of difficulties in ED topics based on ED teachers' perception.
2. To identify students' visual cognitive levels from the aspects of visual perception, visual memory and visualization.
3. To identify the pattern of Engineering Drawing problem solving methods among the students.
4. To develop a Visualization-based Learning Approach based on the pattern of problem solving methods in ED among students of various cognitive visual levels.

Research Methodology

A case study using a survey method was employed in this research. The research instruments used for data collection include 1 set questionnaire and interviews for teachers to determine students' levels of difficulties in ED topics (Phase I); 3 set inventories to identify students' visual cognitive levels and 1 set questionnaire to investigate students' AV problem solving methods (Phase II). Data were analyzed and the results were presented as percentages, frequencies, means and transcripts.

Forty three Engineering Drawing teachers from secondary schools in Johor were selected randomly as samples for the Phase I. The selection of samples was done by proportionate cluster sampling procedure (Wiersma, 1991) and the samples size was based on the Krejcie & Morgan Table (1970). Then, eight teachers with the teaching experience more than 5 years in Engineering Drawing problems were interviewed to determine students' levels of difficulties in ED topics. Purposeful sampling was used to select the samples. Meanwhile, the samples for Phase II consist of 350 students from 9 secondary technical schools (SMT) in Johor. Also, the selection of samples was done same to Phase I sampling technique.

Questionnaire to determine students' levels of difficulties in ED topics consists of 50 items with the reliability index .96. Three set inventories to identify students' visual cognitive levels were visual perception test (30 items and $\alpha = .87$); visual memory test (15 items and $\alpha = .80$) and visual spatial test (30 items and $\alpha = .70$). Whilst the questionnaire to investigate students' AV problem solving methods consists of 13 items with the reliability index .82.

Results and Discussion

Table 1 illustrated the students' levels of difficulties in ED topics based on ED teachers' perception. Findings indicated that 22 teachers (51.2%) agreed that Mekanical Drawing was the highes level of difficulties topic (mean 3.56), followed by intersection vies (mean 3.38) with the numbers of teacher was 15 (34.9%), and then followed by additional views with the mean =.27 with the numbers of teacher was 14 orang (32.6%). Since the mechanical drawing and intersection views are the form five syllabus, the additional views in form four syllabus was the only selection. However, additional views comprised of two subtopics, auxiliary view and rotation view. The results from teachers interview showed that the auxiliary view is more complication compare to rotation views. Thus, the auxiliary view was selected as the focus for this research. This result is similiar to Strong and Smith (2001). They reported that some topics are stated as tough level in ED becasue they need visualization skill to solve the problems.

Table 1: Students' Levels of Difficulties in Engineering Drawing Topics

ED Topics	Levels of Difficulties							
	Easy		Moderate		Tough		Total	
	f	%	f	%	f	%	f	%
1. Sketching	38	88.4	4	9.3	1	2.3	43	100
2. Lines and Lettering	39	90.7	3	7.0	1	2.3	43	100
3. Geometry	33	76.7	10	23.2	0	0	43	100
4. Orthographic Projection	26	60.5	17	39.5	0	0	43	100
5. Additional Views	9	20.9	20	46.5	**14**	**32.6**	43	100
6. Isometric Drawing	30	69.8	10	23.3	3	7.0	43	100
7. Oblique Drawing	16	37.2	25	58.1	2	4.7	43	100
8. Perspective Drawing	12	27.9	19	44.2	12	27.9	43	100
9. Intersection views	12	27.9	16	37.2	**15**	**34.9**	43	100
10. Development Drawing	19	44.2	11	25.6	13	30.2	43	100
11. Section views	10	23.3	22	51.2	11	25.6	43	100
12. Mechanical Drawing	5	11.6	16	37.2	**22**	**51.2**	43	100
13. Building Drawing	17	39.5	22	51.2	4	9.3	43	100
14. Pipe Drawing	15	34.9	16	37.2	12	27.9	43	100
15. Electric Drawing	20	46.5	17	39.5	6	14.0	43	100
16. Electronic Drawing	16	37.2	18	41.9	9	20.9	43	100
17. Computer Aided Drafting	14	32.6	21	48.8	8	18.6	43	100

Notes: f = frequency, % = percentage.

Table 2 to 4 showed the cognitive visual levels from the aspects of visual perception, visual memory and visualization among the SMT students. The results implied that majority of the students were inclined towards the moderate level in visual perception (56%), high level in visual memory (62.8%) and low level in visualization (48.6%).

Table 2: Students' Visual Perception Levels

Visual Perception	Frequency	Percentage	Level
Low	71	20.3	
Moderate	196	56.0	Moderate
High	83	23.7	
Total	350	100.0	

Table 3: Students' Visual Memory Levels

Visual Memory	Frequency	Percentage	Level
Low	44	12.6	
Moderate	86	24.6	High
High	220	62.8	
Total	350	100.0	

Table 4: Students' Visualization Levels

Visualization	Frequency	Percentage	Level
Low	170	48.6	
Moderate	159	45.4	Low
High	21	6.0	
Total	350	100.0	

Table 5: Engineering Drawing Problem Solving Methods among SMT Students

ED Problem Solving Methods	Mean (4.00)
Imagination	3.27
Part Imagination	3.17
Total Imagination	3.20
Sketching	3.18
Part Sketching	3.18
Full Sketching	3.21
Projection Principle	3.19
Mean Total	3.20

Table 5 showed the Engineering Drawing problem solving methods among the students. Results from this study indicated that they use the combination of imagination, sketching and projection principle which resulted in visualization enable these students to search for an alternative solutions that more effectiveness. The Eta(η) and Eta Squared (η2) were used to analyze the association between students cognitive level and ED problem solving methods. The finding indicated that there were significant associate between these two variables. Based on the research finding, a framework for Auxiliary View Problem Solving Method Flow Chart was proposed as illustrated in Figure 1.

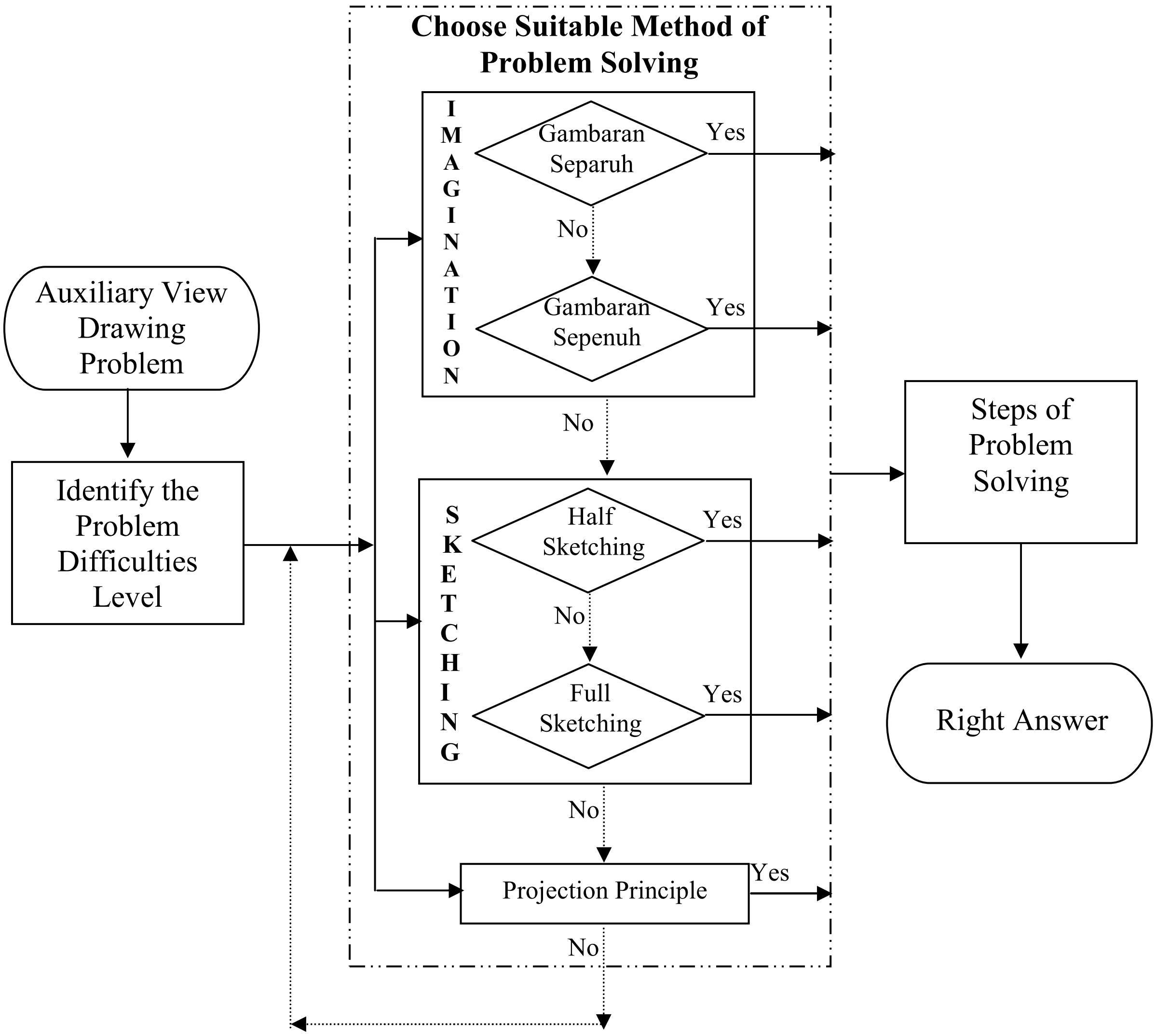

Figure 1: Framework for Auxiliary View Problem Solving Method Flow Chart

A set of auxiliary view test consists of 3 questions was distributed to 350 students to identify the student achievement in this subtopic. The result indicated that majority of the students only scored band 3 with the mean score of 52.5. This research result is similar to the finding of teachers' perception on students' levels of difficulties in ED topics. The chi-square was use to analyze the association between students' achievement in ED and their visual cognitive level. The finding indicated that there were significant associate between these two variables.

Table 6: Students' Achievement in auxiliary view based on Malaysian Open Certificate Marking System (1998)

Achievement Level	Frequency	Percentage
1 (excellent)	16	4.6
2 (good)	27	7.7
3 (good)	213	60.8
4 (weak)	44	12.6
5 (very weak)	50	14.3
Total	350	100.0

After analyzed the research finding, a Visualization-based Learning Approach based on the pattern of problem solving methods in ED among students of various cognitive visual levels was developed as illustrated in Figure 2. The elements in this Visualization-based Learning Approach are clearly explained in Table 7.

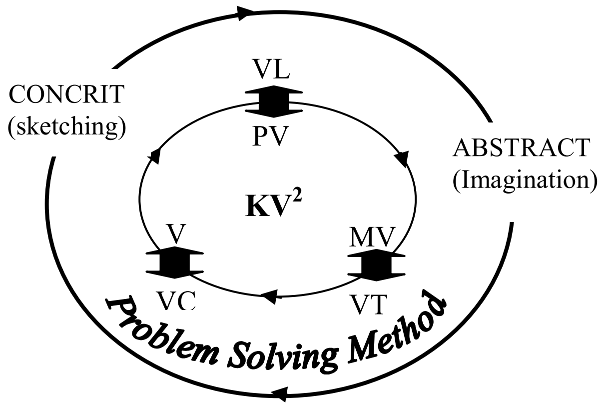

Figure 2: Visualization-based Learning Approach

Table 7: Elements of Visualization-based Learning Approach

Symbols	Elements	Definition
KV^2	Visual Cognitive & Visualization Skill	Combination of characteristics of visual cognitive and visualization skill
PV	Visual Perception	Ability to understand the meaning of visual information that relate to Engineering Drawing.
VL	Visual Learning	Need the student to understand ED concepts visualy.
MV	Visual Memory	Ability to store the information mentaly and call back when it is needed.
VT	Visual Thinking	Need the student to interpret the ED learning content.
V	Visualization	Ability to use the mind in interpreting and thinking an object in 2 or 3 dimension.
VC	Visual Communication	Need student to draw or sketch the object in mind on paper.

Conclusion

Throughout this paper, visual cognitive levels and methods of Engineering Drawing problem solving among selected SMT students were determined. The framework to solve Auxiliary View Problems in Engineering Drawing was proposed and a Visualization-based Learning Approach is developed based on the literature review and the research finding. However, further research need to be conducted to examine the effectiveness of this approach so that the results of this study can be applied in ED teaching and learning for the whole population of SMT students in Malaysia.

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